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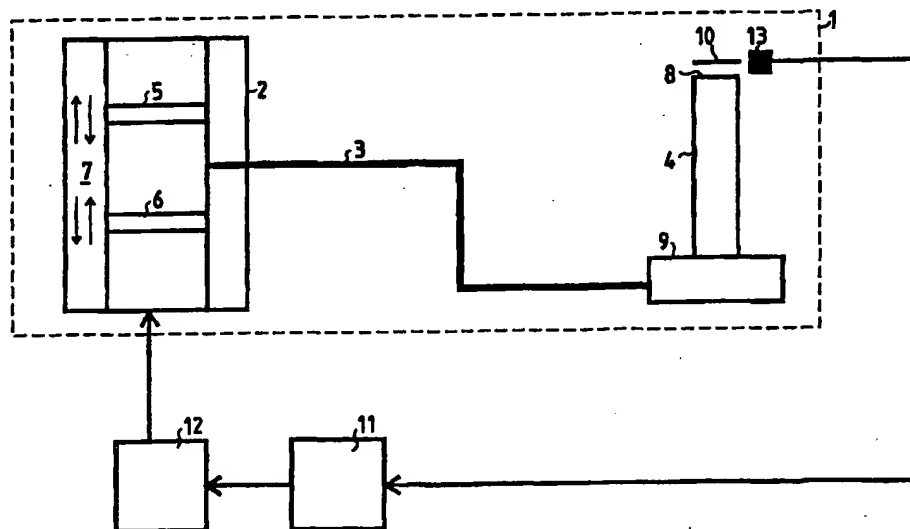
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(21) International Application Number: PCT/EP99/00244 (22) International Filing Date: 6 January 1999 (06.01.99) (30) Priority Data: 1008023 14 January 1998 (14.01.98) NL (71) Applicant (for all designated States except US): HOLLANDSE SIGNAALAPPARATEN B.V. [NL/NL]; Zuidelijke Havenweg 40, P.O. Box 42, NL-7550 GD Hengelo (NL). (72) Inventor; and (75) Inventor/Applicant (for US only): OLBERTZ, Antonius, Hendricus, Maria [NL/NL]; Deldenerstraat 255, NL-7555 AE Hengelo (NL).		(81) Designated States: AU, BR, CA, CN, HU, ID, IL, JP, KR, MX, NO, NZ, PL, RU, SG, TR, UA, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: COOLING DEVICE FOR AN INFRARED DETECTOR



(57) Abstract

The invention relates to a cooling arrangement for cooling an infrared detector. The cooling arrangement functions in an operational mode and a standby mode. In the operational mode, the infrared detector is cooled down to an operational temperature; in the standby mode, the infrared detector is cooled down to a non-operational standby temperature in order to preclude disintegration of the detector elements.

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Cooling device for an infrared detector

The invention relates to a cooling arrangement for an infrared detector.

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Cooling arrangements of this type are for example applied for cooling infrared detectors used in infrared sensors. The sensor may consist of a camera housing which accommodates the infrared detector. A system of lenses  
10 mounted in the camera housing focuses infrared radiation onto the infrared detector. The infrared detector generally comprises a focal plane array of detector elements. For specific applications, diode elements of the type Mercury-Cadmium-Tellurium (Hg-Cd-Te) may serve as detector  
15 elements. This substance is eminently suitable for the long-wave infrared range (8-12  $\mu\text{m}$ ) and the medium-wave infrared range (3-5  $\mu\text{m}$ ). To ensure its proper functioning, the detector array is in operation cooled down to a temperature of 80 Kelvin. To this end, use is made of  
20 cooling arrangements of the type set forth in claim 1.

Widely used in this context are cryogenic cooling arrangements, such as Stirling coolers. Other cooling arrangements are of the Peltier or Joule-Thomson type. In  
25 Peltier cooling arrangements, a Peltier element realizes a certain temperature drop. By connecting several Peltier elements in series, a far greater temperature drop can be realized than would be possible using individual elements. Cooling arrangements of the Joule-Thomson type are based on  
30 the principle of cooling through an expanding gas.

With a view to wear and energy consumption, it is generally inadvisable to leave the cooling arrangement switched on if the sensor is not used. In that case, the cooling  
35 arrangement will be disconnected, which causes the temperature of the infrared detector to rise to an ambient

value. Under certain conditions, the ambient temperature may rise to a high level, caused for example by the action of solar heat on the camera housing the detector. This frequently occurs in military environments, where the  
5 ambient temperature may well exceed 50°C. However, detectors of the (Hg-Ce-Te) type appear to entail the problem that they are subject to disintegration at temperatures exceeding room temperature, due to diffusion effects in the detector diodes. The disintegration rate  
10 will increase in proportion to the temperature. This irrevocably reduces the effectiveness of the detector diodes. This particularly constitutes a problem because these types of detectors are extremely high-priced. Additionally, this will shorten the useful life of the  
15 detector array to a considerable extent. The known cooling arrangements consequently have the drawback of being unsuitable for application in detector arrays whose useful life is seriously shortened when exposed to relatively high temperatures.

20

According to the invention, the cooling arrangement as described in claim 1 obviates this drawback.

The concomitant advantage is that the detector array can be  
25 maintained at an acceptable standby temperature without the cooling arrangement consuming too much energy.

In an special embodiment the cooling arrangement comprises one cooler which, in the standby mode, operates on reduced  
30 cooling power as compared to the operational mode.

A further advantageous embodiment is set forth in claim 3. In this embodiment, the infrared detector temperature is measured and applied to a regulator which controls the  
35 cooling arrangement's power. The regulator maintains the

temperature substantially constant at the values required for use in the operational and standby modes.

A further advantageous embodiment is set forth in claim 6.

- 5 The innovative principle underlying this embodiment is implemented simply by powering fewer Peltier elements in the standby mode than in the operational mode.

- Alternative effective embodiments are set forth in the  
10 claims 7, 8 and 9. These embodiments realize the innovative principle through the application of a main cooler for the operational mode and an auxiliary cooler for the standby mode.

- 15 The invention will now be described in further detail with reference to the following figures, of which:

Fig. 1 represents a split-Stirling cooler incorporating a regulator for controlling the cooling power in two operational modes;

- 20 Fig. 2 represents a split-Stirling cooler incorporating an auxiliary cooler according to the Joule-Thomson principle;

Fig. 3 represents a Peltier cooler incorporating a regulator.

25

- Fig. 1 shows a cooling arrangement according to the invention, incorporating a split-Stirling cooler 1, suitable for use in both operational and standby mode. The split-Stirling cooler comprises a compressor 2 which is  
30 connected to a cold finger 4 via a split tube 3. The cold finger 4 includes a displacer and a regenerator, not shown in the figure. The compressor 2, split tube 3 and cold finger 4 constitute a closed system filled with a cryogenic gas, such as helium. By means of two pistons 5 and 6,  
35 compressor 2 generates a time-varying pressure in the system. Pistons 5 and 6 are actuated by linear

electromotors (not shown here), to which an alternating voltage is applied, which causes both pistons to perform an oscillating motion in opposite directions 7 at the frequency of the alternating voltage and with an amplitude  
5 dependent on the amplitude of the alternating voltage. This time-varying pressure will give rise to four consecutive Stirling cycles in the cold finger 4, i.e.: heat is drawn from the cold side 8 to the warm side 9. As a result, the cold side 8 of the cold finger 4 assumes a temperature of  
10 70 to 80 Kelvin. The cold finger 4 may be positioned in a camera housing provided with a lens (not shown here). The lens focuses infrared radiation onto a staring array 10 of detection diodes of the Hg-Cd-Te (Mercury-Cadmium-Tellurium) type, attached to the cold side of the cold  
15 finger.

The cooling power for the cooling arrangement is controlled/governed by varying the amplitude of the compressor piston motion. To this end, a regulator 11 is  
20 provided to actuate an amplifier 12 which generates the alternating voltage for the compressor motor. Regulator 11 comprises a selector switch, not shown here, to allow the cooling arrangement to function in the operational mode or in the standby mode. In the operational mode, the cooling  
25 power is controlled such that the cold side of the cold finger 4 attains a temperature of approximately 70 or 80 Kelvin; the temperature in the standby mode may range from -20 to 40 degrees Celsius, but shall preferably not exceed 20 degrees Celsius. The cold side 8 of the cold  
30 finger may be provided with a temperature sensor 13, connected to the regulator 11. Regulator 11 will, based on temperature measurements, adjust the cooling power to the desired value.

35 Fig. 2 represents an alternative embodiment of the cooling arrangement according to the invention. The cooling

arrangement comprises a main cooler, implemented, in the example to the embodiment, as a split-Stirling cooler 2, 3, 4 and an auxiliary cooler 14, in the example implemented as a cooler that operates according to the Joule-Thomson principle. Via a supply line 15, an expanding gas is blown along the staring array 10. In the operational mode, the main cooler cools staring array 10 until an operating temperature of 70 to 80 Kelvin is attained. In the standby mode, the main cooler is disconnected and the auxiliary cooler 14 activated. The cooling capacity of the auxiliary cooler is sufficient to prevent disintegration of staring array 10.

Fig. 3 shows an embodiment of the invention where the cooling arrangement comprises a stack of Peltier elements  $E_1, \dots, E_n$ . Each Peltier element  $E_i$  realizes a certain temperature drop. A staring array 10 to be cooled is disposed on top of the stack. The Peltier elements are individually powered through connections  $A_1, \dots, A_n$  by means of a power source 16. The power source has an operational mode and a standby mode. In the operational mode, all Peltier elements are powered; in the standby mode only a limited number, although this number of elements is sufficient to maintain the staring array at a temperature at which array disintegration is virtually impossible. Preferably, only those Peltier elements that are in closest proximity to staring array 10 are connected, for example the first three elements. The side to be cooled may be provided with a temperature sensor (not shown in the figure) to be hooked up to a power source which either connects or disconnects Peltier elements on the basis of the temperature sensor measurements.

Claims:

1. Cooling arrangement for an infrared detector for cooling, in an operational mode, the infrared detector to  
5 at least substantially an operational temperature T1, characterized in that the cooling arrangement is also designed for cooling, in a standby mode, the infrared detector to at least substantially a standby temperature T2, whereby T2 is considerably higher than T1.
- 10 2. Cooling arrangement as claimed in claim 1, characterized in that said arrangement incorporates one cooler which, in the standby mode, operates on reduced cooling power as compared to the operational mode.
- 15 3. Cooling arrangement as claimed in claim 2, characterized in that said arrangement comprises a temperature sensor for measuring a temperature of the infrared detection element and a regulator for controlling the cooling power, in both  
20 operational and standby mode, in response to signals from the temperature sensor.
4. Regulator for incorporation in a cooling arrangement as claimed in claim 3.
- 25 5. Cooling arrangement as claimed in claim 3, characterized in that the cooler is a Stirling, a Joule-Thomson or a Peltier type of cooler.
- 30 6. Cooling arrangement as claimed in claim 2, characterized in that said arrangement comprises a number of Peltier elements connected in series and that the cooling power can be effectively reduced by powering fewer Peltier elements in the standby mode than in the operational mode.

7. Cooling arrangement as claimed in claim 1, characterized in that said arrangement comprises a main cooler for cooling the infrared detector in the operational mode and an auxiliary cooler for cooling the infrared detector in  
5 the standby mode.

8. Cooling arrangement as claimed in claim 7, characterized in that the auxiliary cooler is of the Joule-Thomson type.

10 9. Cooling arrangement as claimed in claim 7, characterized in that the auxiliary cooler comprises a supply line for the supply of an expanding gas to the infrared detector.

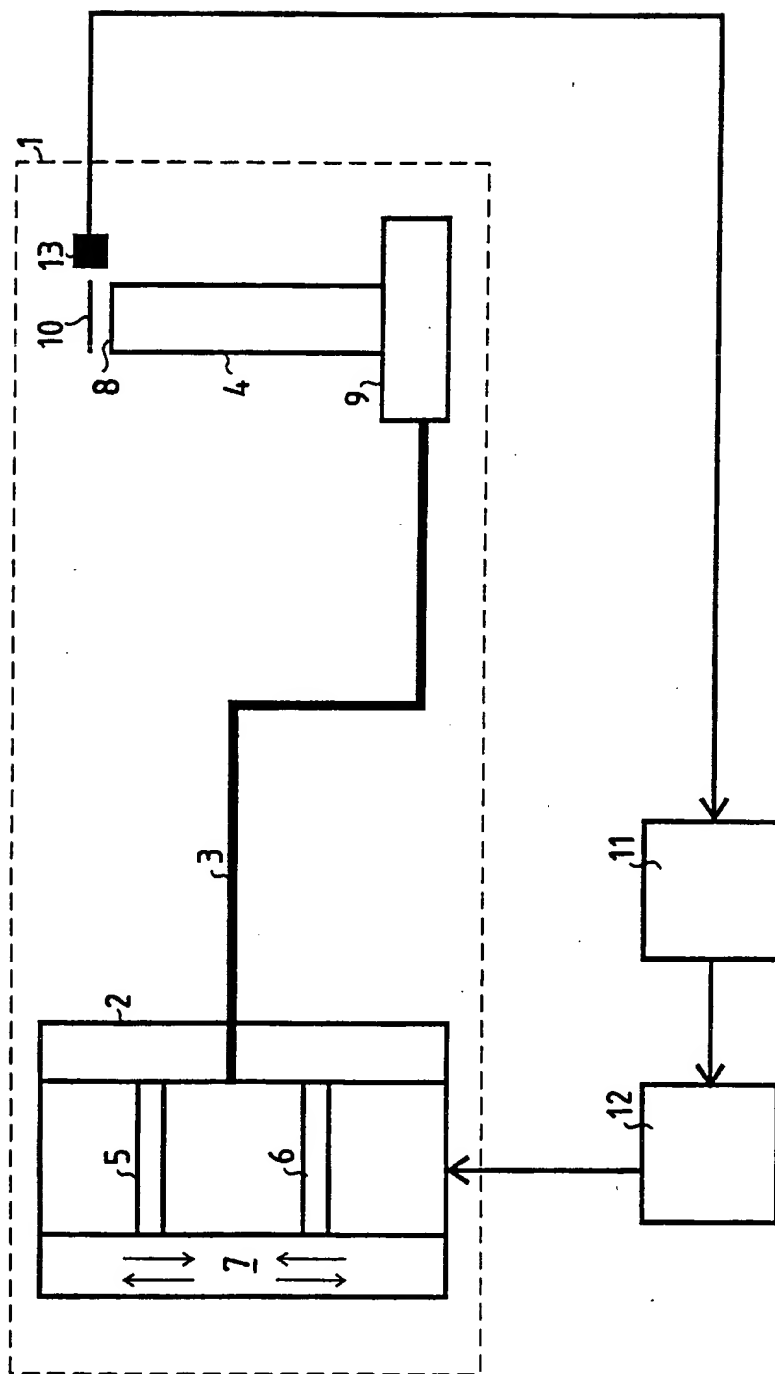


FIG. 1

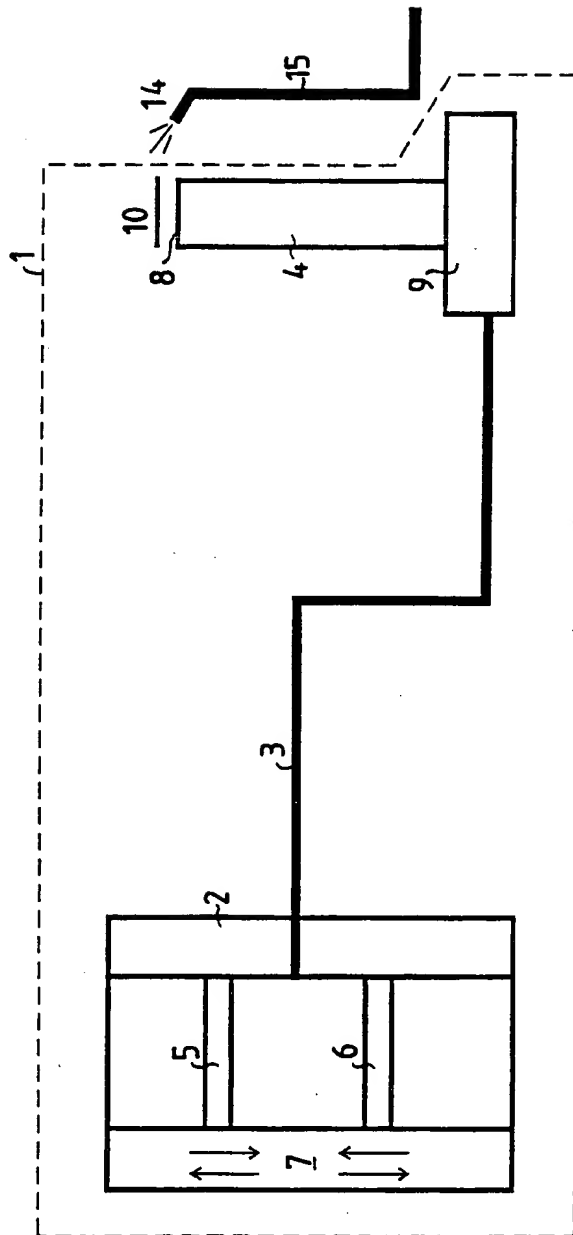
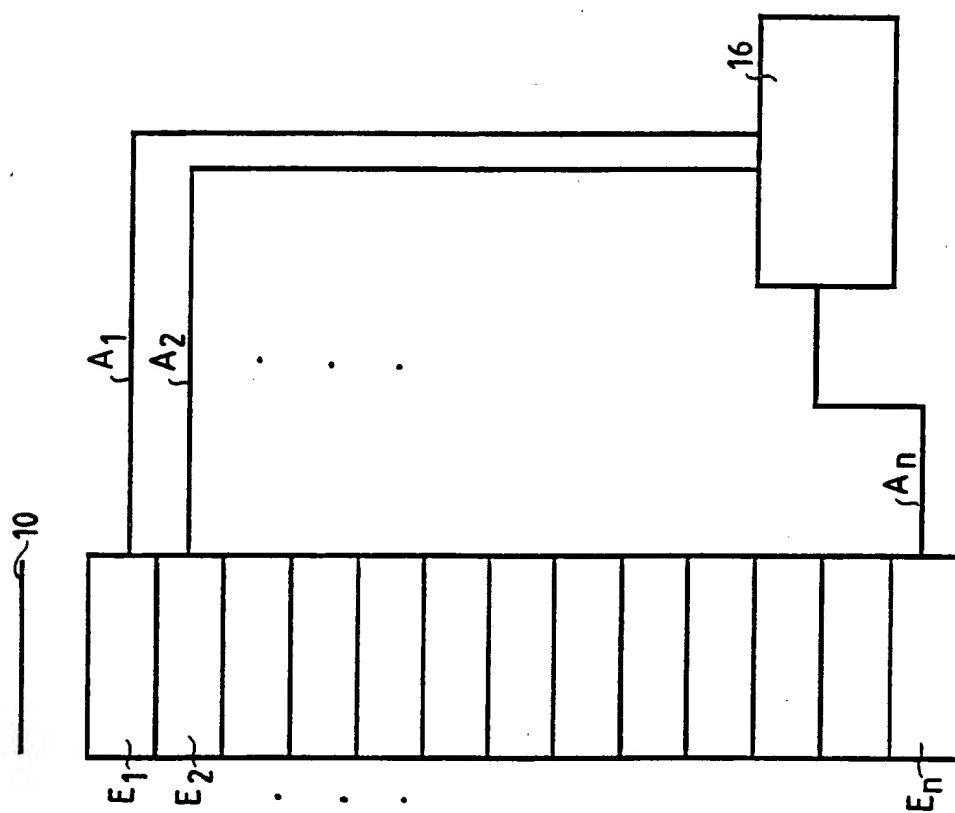


FIG. 2

FIG. 3



# INTERNATIONAL SEARCH REPORT

Interr. nat. Application No

PCT/EP 99/00244

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H01L23/38 F25D19/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H01L F25D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 361 011 A (CALLENDER ROBERT E ET AL) 30 November 1982 see the whole document	1-5
Y	---	6
Y	PATENT ABSTRACTS OF JAPAN vol. 018, no. 336 (E-1568), 24 June 1994 & JP 06 085122 A (FUJITSU LTD), 25 March 1994 see abstract	6
A	US 5 365 746 A (WARNER H BURT ET AL) 22 November 1994 see column 1, line 28 - column 2, line 16 see column 3, line 28 - line 49 --- -/--	1,2,7-9

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>DE 195 38 664 A (AIR LIQUIDE)  25 April 1996  see figures 2,5-7  see column 1, line 1 - line 35  see column 2, line 37 - line 49  see column 3, line 27 - line 63  see column 10, line 30 - column 11, line 13</p> <p style="text-align: center;">-----</p>	1,2,5-7

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Information on patent family members

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